National Aeronautics and
Space Administration

Aeronautics

Robust, Optimal Subsonic Airfoil Shapes

Aerodynamic Design Using Neural Networks

This invention relates to design of optimal shapes of airfoils, such as turbine blades, operating in subsonic flow regimes. An airfoil, such as a propeller blade or a turbine vane or blade (collectively referred to herein as an "airfoil"), may be used in a variety of environments, including different ambient temperatures, gas densities, gas compositions, gas flow rates, pressures, and motor rotational speeds. An airfoil shape that is optimized for one environment may have sharply limited application in another environment. This invention is robust enough to provide designs of airfoils that operate satisfactorily in any class of environments and with any reasonable differences from manufacturing specifications, and which satisfy the constraints imposed on the design.

BENEFITS

- Optimized for any gas environment
- Flexible
- Extendible
- Optimized airfoil shape is thicker and stronger
- Shedding resonance response is eliminated

technology solution

THE TECHNOLOGY

This invention provides a method, and a product produced by the method, for determination of a robust, optimal subsonic airfoil shape, beginning with an arbitrary initial airfoil shape and imposing the necessary constraints on the design. In one embodiment, the method implements the following steps or processes: (1) provide a specification of a desired pressure value at each of a sequence of selected locations on a perimeter of a turbine airfoil; (2) provide an initial airfoil shape; (3) provide a statement of at least one constraint that a final airfoil shape must conform to; (4) use computational fluid dynamics ("CFD") to estimate a pressure value at each of the selected perimeter locations for the initial airfoil shape; (5) use computational fluid dynamics (CFD) to determine the pressure distribution for airfoil shapes that are small perturbations to the initial airfoil shape; (6) use an estimation method, such as a neural network, a support vector machine, or a combination thereof, to construct a response surface that models the pressure distribution that is closer to the specified target pressure distribution; (7) use an optimization algorithm to search the response surface for the airfoil shape having a corresponding pressure distribution ; and (8) provide at least one of an alphanumeric description and a graphical description of the modified airfoil shape.

Internal Rotor of a Steam Turbine

APPLICATIONS

The technology has several potential applications:

- Aerospace and Transportation vehicles
- Industrial and Dynamic Machinery
- Aeronautical Engineering
- Mechanical Engineering
- Power Plant turbo machinery

PUBLICATIONS

Patent No: 7,454,321; 7,293,001; 6,606,612; 7,191,161

More Information

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